CHAPTER 6 ENERGY INDICATORS

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Introduction

Energy is a critical component of every aspect of Washington's economy and is used daily by every resident of the state to meet the most basic human needs. Energy lights and heats our homes, cooks our food, fuels our vehicles, and powers our industries. But few of us have a thorough understanding of key trends taking place in this crucial industry. This section presents a series of 24 "Energy Indicators", illustrating some of the most important long-term energy trends. Each indicator consists of a chart based on readily available energy, economic, and demographic information, a caption highlighting key trends depicted in the chart, and narrative giving additional perspective or describing further aspects of the indicator.

This is the first update of the Energy Indicators, which were first published in 1999 as part of the 1999 Biennial Energy Report. The Indicators began as a successor to the *Washington State Energy Use Profile*, which was published periodically in the past by the Washington State Energy Office, most recently in June of 1996. The Indicators combine energy, economics and demographic data into a series of charts and graphs, each of which portrays a distinct view of Washington's energy picture.

In order to ensure that the Energy Indicators presented here are grounded in the best available information and can be updated on a regular basis, they are based exclusively on regularly published data from sources in the public domain. The U.S. Energy Information Administration (EIA) has the most complete sources of annual, state-level energy data. Our principal source is the EIA's Combined State Energy Data System (CSEDS), the database used to publish the State Energy Data Report (SEDR) and the State Energy Price and Expenditure Report (SEPER). Additional sources are listed at the end of this chapter.

Collecting and publishing detailed statistics on energy consumption, price, and expenditures for fifty states and the District of Columbia is a large task produced after work done on fuel-specific data, thus comprehensive state information from EIA lags by two to three years. Consequently, the Energy Indicators are confined to analysis of long-term energy trends. The impacts of the dramatic increases in the market prices of electricity and natural gas that occurred during the second half of 2000 are discussed in other chapters of this report, and will be addressed in future versions of Washington's Energy Indicators.

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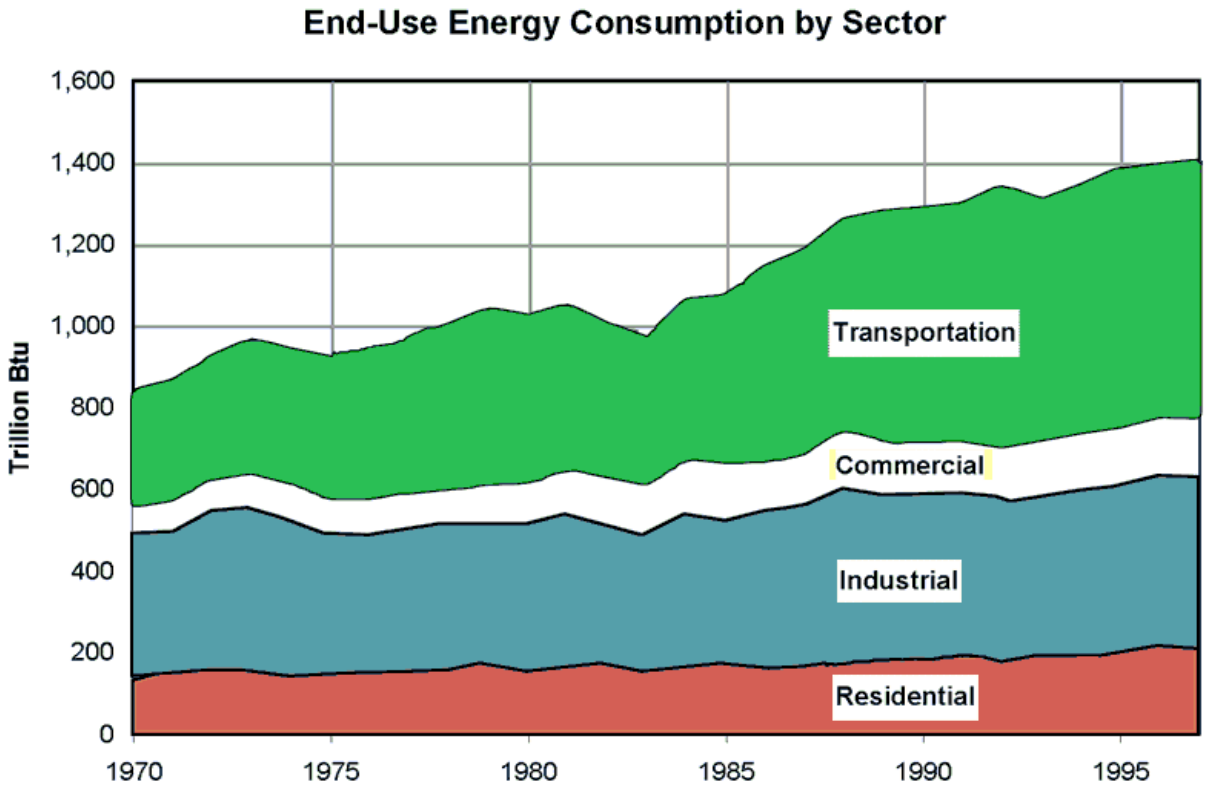
1. Washington's Energy Use — End-Use Energy Consumption



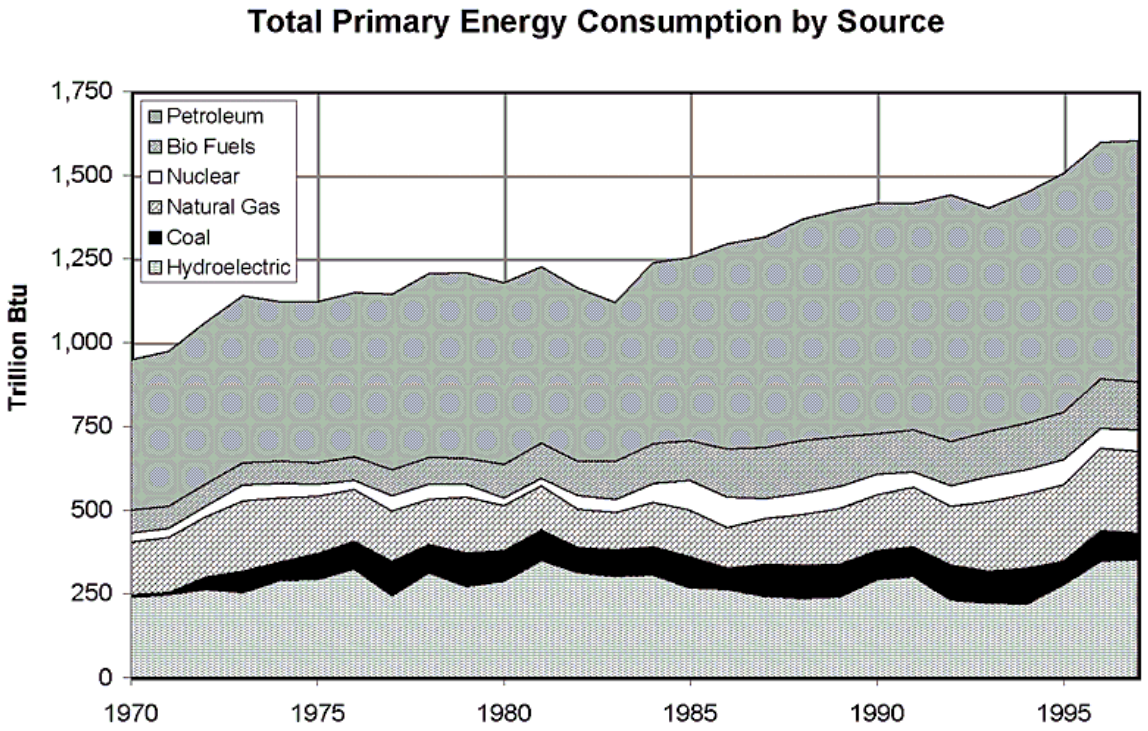
END USE ENERGY CONSUMPTION IN WASHINGTON WAS TWO-THIRDS HIGHER IN 1997 THAN IN 1970. MOST OF THE INCREASE OCCURRED IN THE TRANSPORTATION SECTOR, WHERE ENERGY USE HAS MORE THAN DOUBLED SINCE 1970. TRANSPORTATION NOW ACCOUNTS FOR CLOSE TO HALF OF THE STATE'S ENERGY CONSUMPTION.

Washington's end-use energy consumption grew at 1.3% per year between 1993 and 1997, reaching an all-time high of 1.4 quadrillion Btu in 1997. The transportation sector accounts for the largest share of growth in energy consumption, growing at an annual rate of 3.7% since 1985.

During the 1970s and early 1980s, growth in energy consumption was dampened by higher energy prices and changes in the state's economy. Industrial sector energy consumption was nearly flat between 1970 and 1985. Energy consumption in the commercial sector, which includes service industries such as software, finances and insurance, more than doubled over the same period, but remains small relative to other sectors.

The period since 1985 has been characterized by modest growth in the residential and industrial sectors, where energy consumption grew at 1.5% per year between 1985 and 1997, and rapid growth in the transportation sector of 3.7% per year. After spiking in the late 1970s and early 1980s, energy consumption in the commercial sector has been nearly flat since 1985.

2. Washington's Energy Use — Primary Energy Consumption

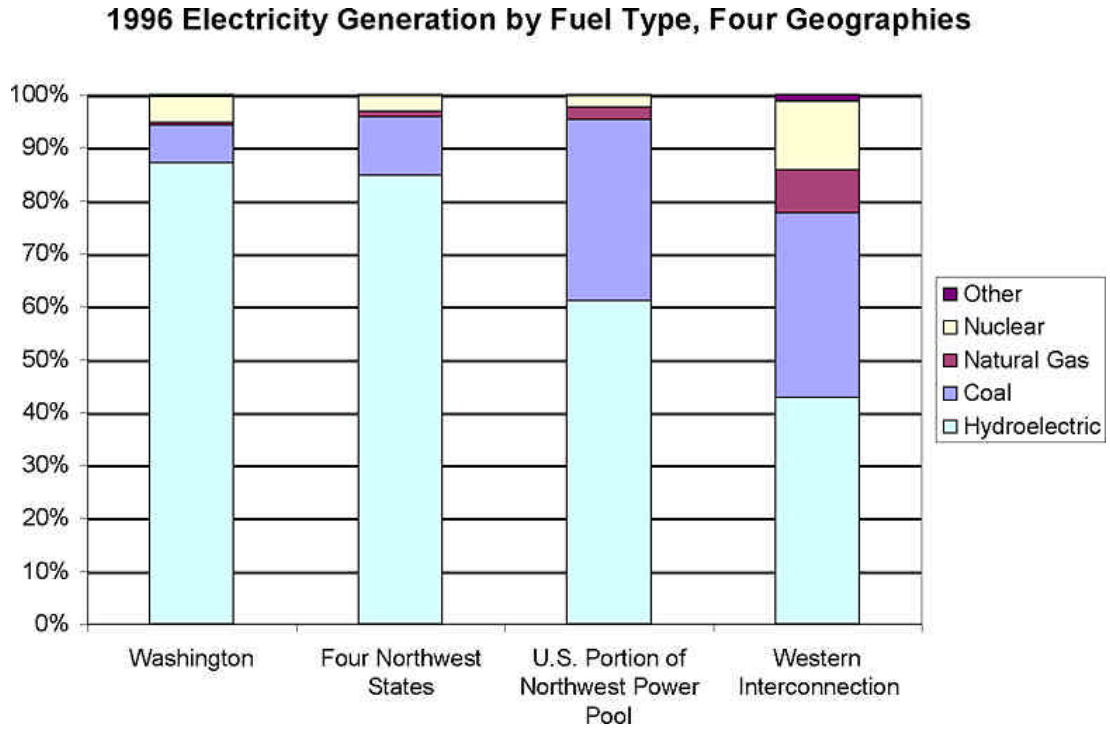


WASHINGTON CONTINUES TO RELY ON PETROLEUM FUELS TO MEET ABOUT HALF ITS ENERGY NEEDS. THE RELATIVE CONTRIBUTION OF HYDROELECTRICITY AS AN ENERGY SOURCE HAS DECLINED[1].

This indicator shows the extent of Washington's reliance on six major primary[2] energy sources: petroleum, hydroelectricity, natural gas, biofuels, coal, and uranium. Washington continues to rely on petroleum, more than three-quarters of which is imported by tanker from Alaska, to meet 45% of its primary energy needs. This share has not changed appreciably since 1970. Hydroelectricity's relative importance has declined since the mid 1980s; while total generation from hydroelectric dams has stayed relatively constant, consumption of fossil fuels has grown rapidly. Natural gas consumption doubled between 1983 and 1995, regaining the market share it lost during the 1970s. Natural gas now accounts for nearly 15% of Washington's primary energy consumption. Biofuels, mainly wood and wood waste products, account for 8% of primary energy consumption.

These fuels are primarily burned for steam and cogeneration at pulp and paper mills. Coal is consumed almost exclusively at the Centralia Steam Plant, while uranium is used at the Energy Northwest's Columbia Generating Station plant in Richland. Together, coal and nuclear generation accounted for 9% of Washington's primary energy supply in 1997.

3. Washington's Energy Use — Electricity Generation



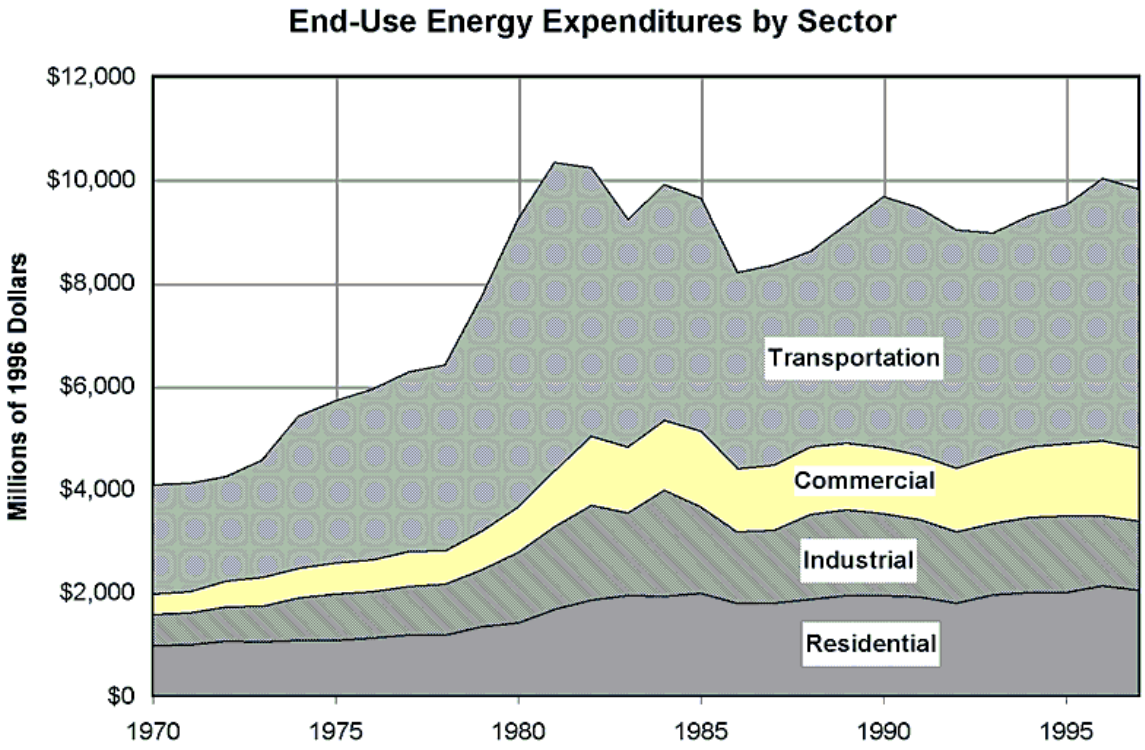
WHILE 85% OF ELECTRICITY GENERATED IN WASHINGTON COMES FROM HYDROELECTRIC DAMS, WASHINGTON CONSUMERS ARE SERVED BY ELECTRICITY FROM GENERATING PLANTS LOCATED THROUGHOUT THE WESTERN INTERCONNECTION. MANY OF THESE PLANTS ARE FIRED BY COAL OR NATURAL GAS.

How much of Washington's electricity is hydro? The answer depends on how one defines "Washington's electricity". While hydroelectric dams accounted for 85% of the electricity generated in Washington in 1996, Washington is part of an interconnected, regional bulk power system and Washington consumers are dependent on coal, natural gas, and nuclear plants in other states. Moreover, much of the hydroelectric generation in Washington is owned by the federal government and operated on behalf of customers in multiple states.

A better proxy for "Washington's electricity" might be the mix of generation in the U.S. portion of the Northwest Power Pool (NWPP.)[1.] This incorporates coal plants in Oregon, Montana, Wyoming, and Utah owned by utilities that serve Washington customers. Hydroelectric dams accounted for 61% of NWPP generation in 1996, while 34% came from coal-fired plants.

However, this still ignores seasonal purchases and exchanges of nuclear, coal, and gas-fired electricity from the Southwest. The 1996 generation mix for the U.S. portion of the Western Interconnection[2] was 43% hydro, 35% coal, 13% nuclear, and 8% natural gas.

4. Washington's Energy Bill — End Use Energy Expenditures

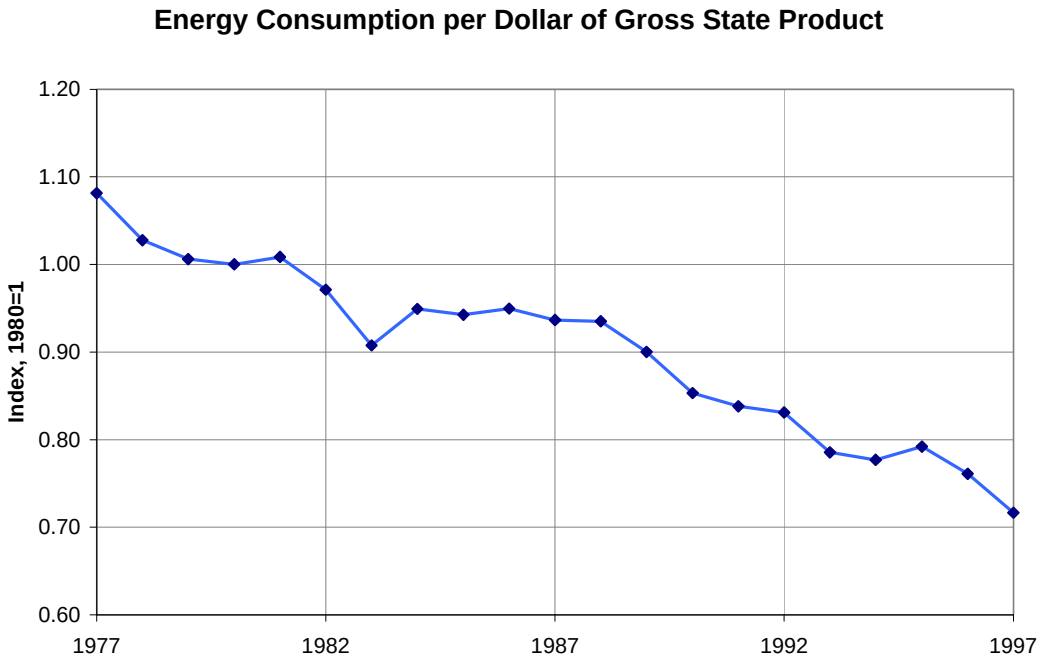


ADJUSTED FOR INFLATION, ENERGY EXPENDITURES IN WASHINGTON IN 1997 WERE JUST 6% HIGHER THAN IN 1980, DESPITE A 37% INCREASE IN ENERGY CONSUMPTION DURING THAT PERIOD.

Washingtonians spent $9.8 billion on energy in 1997. While that represents a 60% increase over 1980 in nominal terms, when adjusted for inflation the amounts are very similar, despite a 37% increase in energy consumption. Energy prices have not kept pace with inflation since oil and gas prices peaked in the early 1980s. This period contrasts sharply to the 1970s, when expenditures on energy increased by 150% in real terms.

The transportation sector accounts for the largest share of energy expenditures, 45% in 1997. This proportion declined, however, from over 60% in 1980, even as transportation's share of statewide energy consumption increased. The real price of petroleum fuels declined significantly between 1980 and 1997, while the price of electricity, the largest energy source in the residential and commercial sectors, stayed constant.

5. Washington's Energy Intensity — Energy Consumption per Dollar of Gross State Product

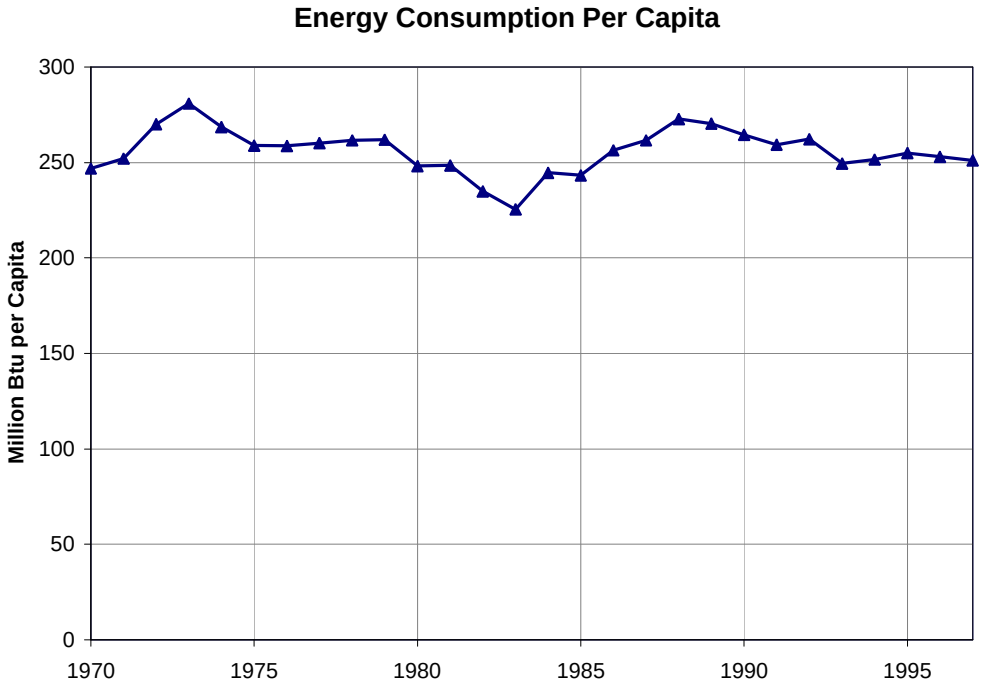


WASHINGTON CONTINUES TO PRODUCE MORE REAL VALUE IN GOODS AND SERVICES PER UNIT OF ENERGY CONSUMED, DESPITE GROWTH IN TOTAL ENERGY CONSUMPTION. KEY REASONS ARE A SHIFT IN THE STATE'S ECONOMY TO HIGH-VALUE BUSINESSES THAT ARE LESS ENERGY-INTENSIVE AND IMPROVED PROCESS EFFICIENCY.

This measure of the overall energy intensity of Washington's economy depicts the amount of energy we use to produce a dollar's worth of economic output. Washington energy consumption is divided by real Gross State Product (GSP), the sum of all goods and services produced in the state, and the result is indexed so that the value in 1980 is equal to one. Despite the rapid increase in Washington's total energy consumption between 1980 and 1997, energy consumption per dollar of GSP declined by 28% over the period.

Washington's economy is growing faster than its energy consumption, and has been since at least 1977, when the Gross State Product data series we use begins. This is due to a number of factors, chief among them a shift in the state's economy from resource and manufacturing industries to commercial activity based on software, biotech, and other, less energy intensive businesses. Gains in energy efficiency have also contributed.

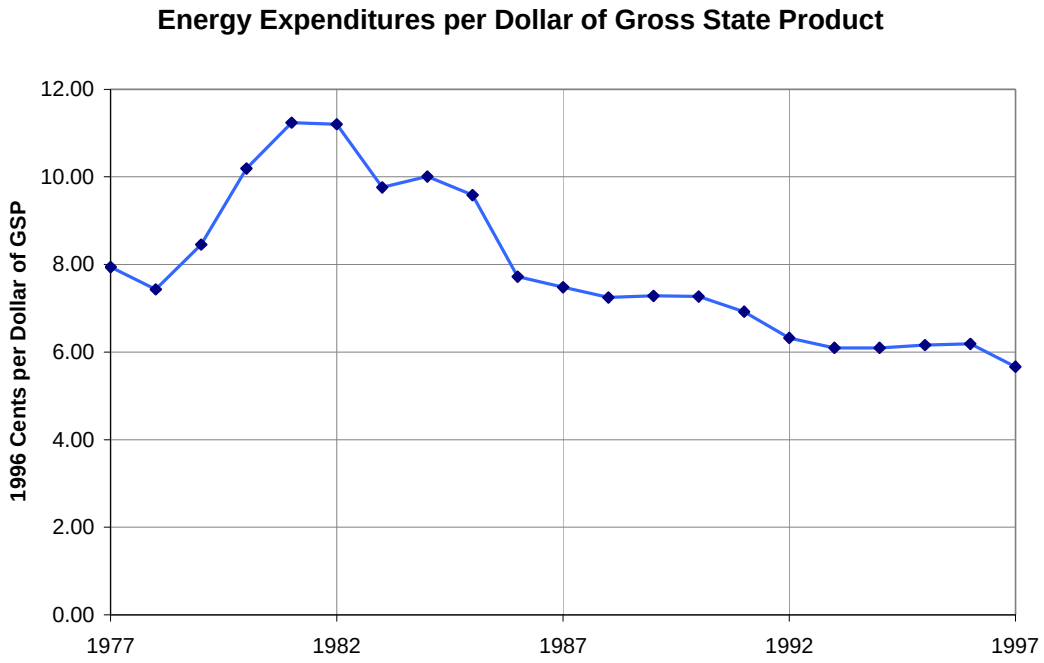
6. Washington's Energy Intensity — Energy Consumption per Capita



ENERGY CONSUMPTION PER CAPITA IS SIMILAR TODAY TO LEVELS IN 1970. EXCEPT AT THE DEPTHS OF THE EARLY-1980S RECESSION, ENERGY CONSUMPTION PER CAPITA IN WASHINGTON HAS STAYED RELATIVELY CONSTANT SINCE THE 1970S.

Another way to look at Washington's energy intensity is energy consumption per capita. While the previous indicator demonstrated that Washington continues to create more wealth per unit of energy, here the story is somewhat different. Washington's per capita energy consumption in 1997 was 250 million Btu. That's the equivalent of about 2000 gallons of gasoline per person, and is identical to the figure for 1971. Energy consumption per capita declined by about 25% between 1973 and 1983, to a low of 225 million Btu per person in 1983. This was followed by a period of rapid growth between 1983 and the end of the decade. Most of the increase occurred in transportation fuels, as communities began to sprawl and Washingtonians drove more and more miles per year. Per capita energy consumption was relatively flat through the first eight years of the 1990s.

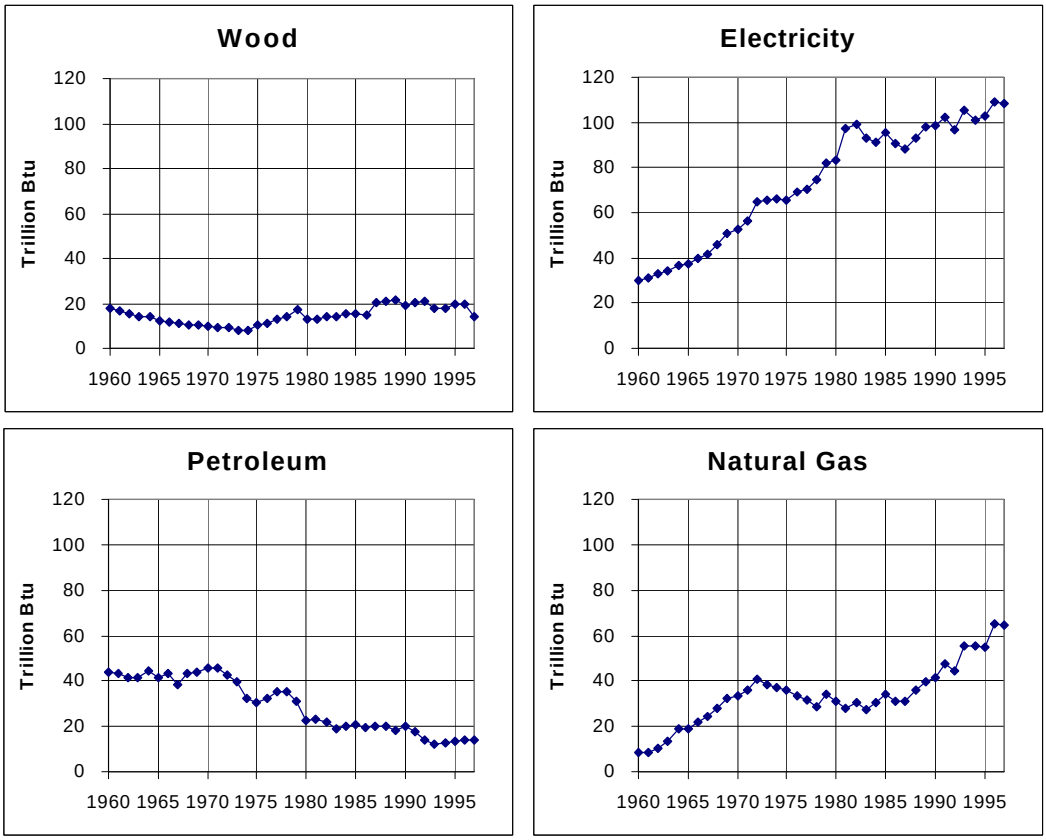
7. Washington's Energy Intensity — Energy Expenditures and Gross State Product



ENERGY EXPENDITURES ARE DECLINING RELATIVE TO ECONOMIC OUTPUT, DESPITE GROWTH IN ENERGY CONSUMPTION[1]. PRINCIPAL CAUSES ARE DECLINING ENERGY INTENSITY AND LOWER ENERGY PRICES.

This indicator divides statewide energy expenditures by economic output, in the form of Gross State Product. The result is an estimate of the significance of energy in Washington's economy. Approximately 5.6¢ is spent on energy in Washington for every dollar of gross state product. This number has been declining steadily since peaking at 11¢ in 1981. Two trends have contributed to this decline: Washington's economy is becoming less energy-intensive and real energy prices have declined. In 1997, energy expenditures were smaller relative to Washington's economy than at any time in history.

8. Residential Sector Trends — End-Use Energy Consumption by Fuel

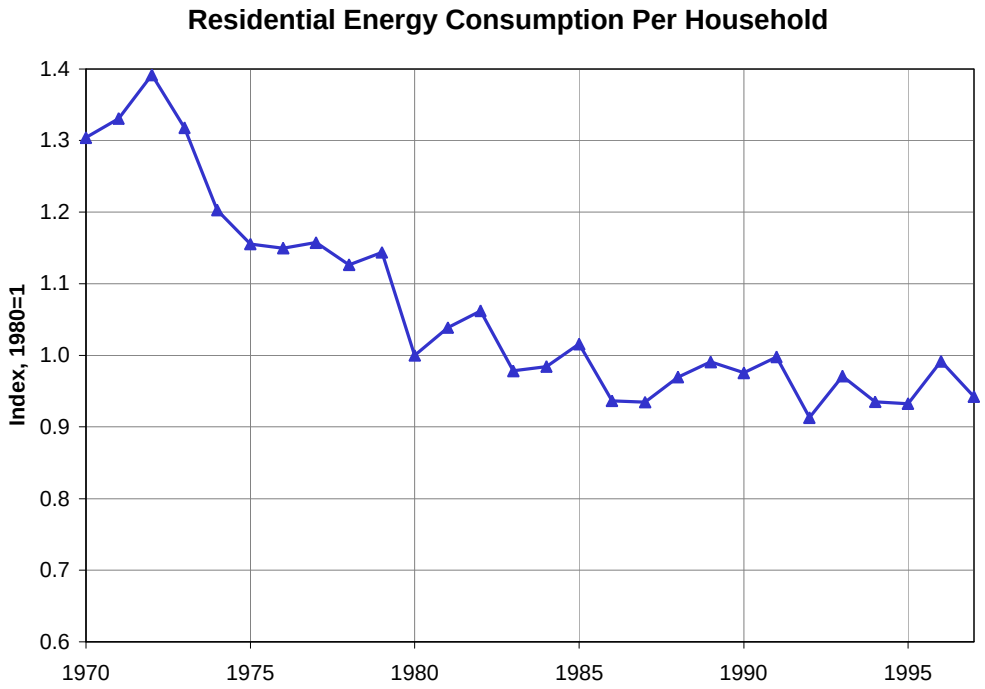


GROWTH IN HOUSEHOLD ELECTRICITY CONSUMPTION HAS SLOWED IN THE LAST 16 YEARS, WHILE GROWTH IN NATURAL GAS USE HAS ACCELERATED. OIL CONSUMPTION CONTINUES TO DECLINE,[1] BUT NEW ESTIMATES INDICATE SURPRISING STABILITY IN WOOD USE.

Electricity accounts for the majority of residential energy consumption, but average electricity use per household has declined since 1980. Growth in natural gas consumption has accelerated; residential sector gas use grew at 1.9% per year between 1980 and 1985, 3.9% per year between 1985 and 1990, and 6.5% per year between 1990 and 1997. Propane use has grown considerably in recent years as well, but is masked here by the decline in heating oil, which fell from more than 43% of household consumption in 1960 to less than 7% in 1997.

Consumption of firewood grew in the late 1970s in response to high heating oil prices. Despite environmental restrictions and the increasing popularity of gas appliances, estimates of wood consumption have remained remarkably high and stable since rising again in the late 80's.

9. Residential Sector Trends — Household Energy Intensity

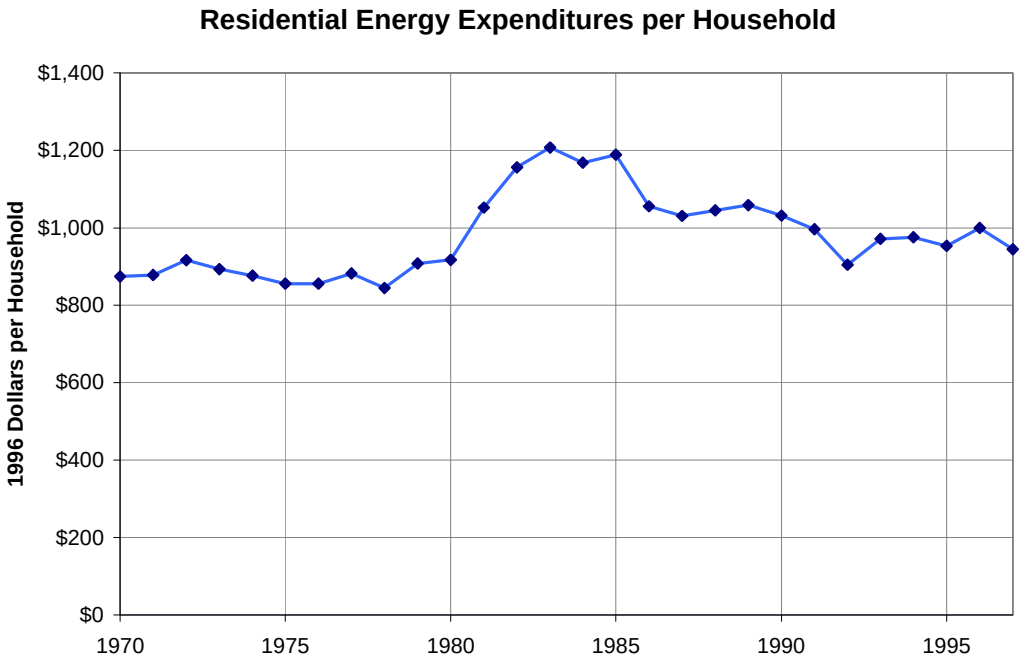


ENERGY CONSUMPTION PER WASHINGTON HOUSEHOLD HAS DECLINED BY ALMOST A THIRD SINCE PEAKING IN 1972, INDICATING AN IMPROVEMENT IN HOUSEHOLD ENERGY EFFICIENCY. GAINS HAVE SLOWED IN RECENT YEARS.

Washington households became much more energy efficient between 1970 and 1985, with a slower decline since. The 1970s were characterized by diminished oil and natural gas consumption, with natural gas use per household falling by 33% between 1970 and 1980. Oil consumption dropped from 300 gallons per household in 1970 to 85 in 1983, with half the decline occurring after the second oil shock in 1978. The data indicate an increased reliance on wood and electricity as space heating fuels during the late 1970s and early 1980s. Concerted efforts to improve residential efficiency through building standards and codes began in earnest in the mid-80s. Despite larger houses, more widespread use of air conditioning, and the significant proliferation of electricity-using appliances, electricity consumption per household declined by 7% between 1985 and 1997.

The trend toward lower household energy consumption has slowed recently, as declines in wood and petroleum consumption during the 1990s have been offset by increasing natural gas consumption. Moreover, these data do not include energy used for personal transportation, which has increased markedly during the last fifteen years.

10. Residential Sector Trends — Household Energy Bill



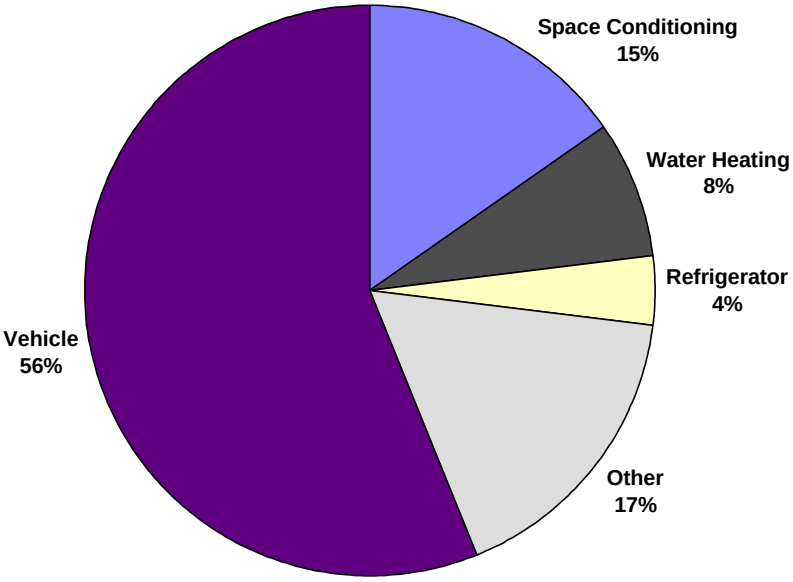
ADJUSTED FOR INFLATION, THE AVERAGE WASHINGTON HOUSEHOLD SPENT 8% MORE FOR HOME ENERGY IN 1997 THAN IN 1970. IMPROVEMENTS IN HOUSEHOLD ENERGY EFFICIENCY AND FUEL SWITCHING TO LESS EXPENSIVE ENERGY SOURCES HAVE OFFSET HIGHER ELECTRICITY PRICES.

In 1997, the average Washington household spent the inflation-adjusted sum of $944 for electricity, natural gas, and petroleum delivered to the home, roughly $70 more than in 1970. This outward similarity masks significant changes in the composition of household energy expenditures over the last 25 years. Increased emphasis on energy conservation and fuel switching from heating oil to wood helped to mitigate the impact of the oil shocks of the 1970s on the home energy bill of Washington households. However, there is no immediate substitute for electricity, so when electricity prices increased by 62% between 1980 and 1983, due largely to the inclusion in rates of the WPPSS nuclear bonds, the average household electricity bill increased by a like amount.

Over time, energy efficiency and fuel switching have helped reduce reliance on relatively expensive electricity. The electricity bill for the average Washington household dropped by 17% between 1985 and 1997; usage per household fell 7%. Many new homes were built with natural gas heat and numerous existing households saved by switching to natural gas as well. Switching to a cheaper fuel could mean significant savings; the average natural gas bill fell by 10% between 1985 and 1997, despite a 45% increase in per household consumption.

11. Residential Sector Trends — Household Energy Bill with Transportation

Household Energy Bill by End Use 1997 ($2,200)

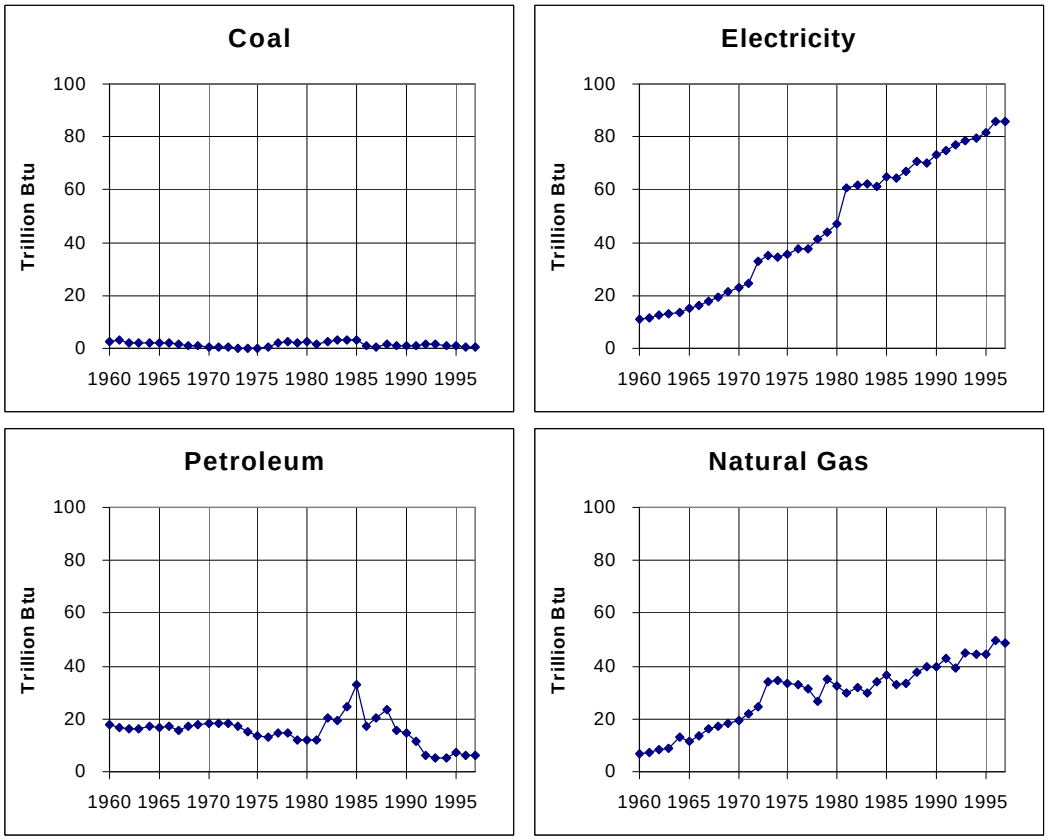


BY INCLUDING ENERGY USED FOR PERSONAL TRANSPORTATION, THE ANNUAL ENERGY BILL FOR THE AVERAGE WASHINGTON HOME MORE THAN DOUBLES[1].

Most views depicting residential energy data do not include the major components of consumption and expenditure at most homes – household vehicles. The average household in Washington spent 56% of its energy budget fueling vehicles for transportation in 1997. This share has increased dramatically in the last two decades. While homes are becoming more energy efficient, they are increasingly located at longer distances from where people work, shop, and recreate.

After personal transportation, major categories of household energy expenditures include space conditioning (heating, cooling, and ventilation), water heating, refrigerators, and other uses such as lighting, household appliances, and electronic equipment.

12. Commercial Sector Trends — End-Use Energy Consumption by Fuel

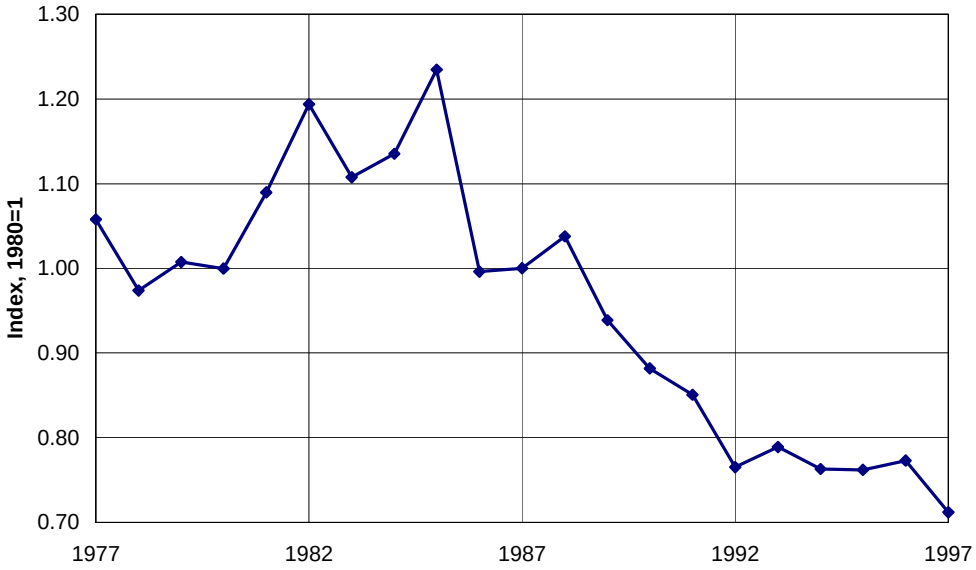


ELECTRICITY ACCOUNTS FOR OVER 60% OF END-USE ENERGY CONSUMPTION IN THE COMMERCIAL SECTOR. NATURAL GAS MAKES UP THE BULK OF THE REST. BOTH GAS AND ELECTRICITY CONSUMPTION CONTINUE TO GROW AT 2% PER YEAR.

Electricity and natural gas are the dominant fuels in Washington's commercial sector. With escalating use of electricity-consuming equipment such as computers, printers, and photocopiers, the commercial sector has become increasingly reliant on electricity during the last two decades. Commercial sector electricity consumption has nearly quadrupled since 1970. Natural gas lost market share in the late 1970s and early 1980s, but has recovered rapidly since 1985. In contrast, petroleum consumption is less than half of early 1970s levels, declining from 30% of commercial energy consumption in 1970 to around 5% in 1995.

13. Commercial Sector Trends — Commercial Sector Energy Intensity

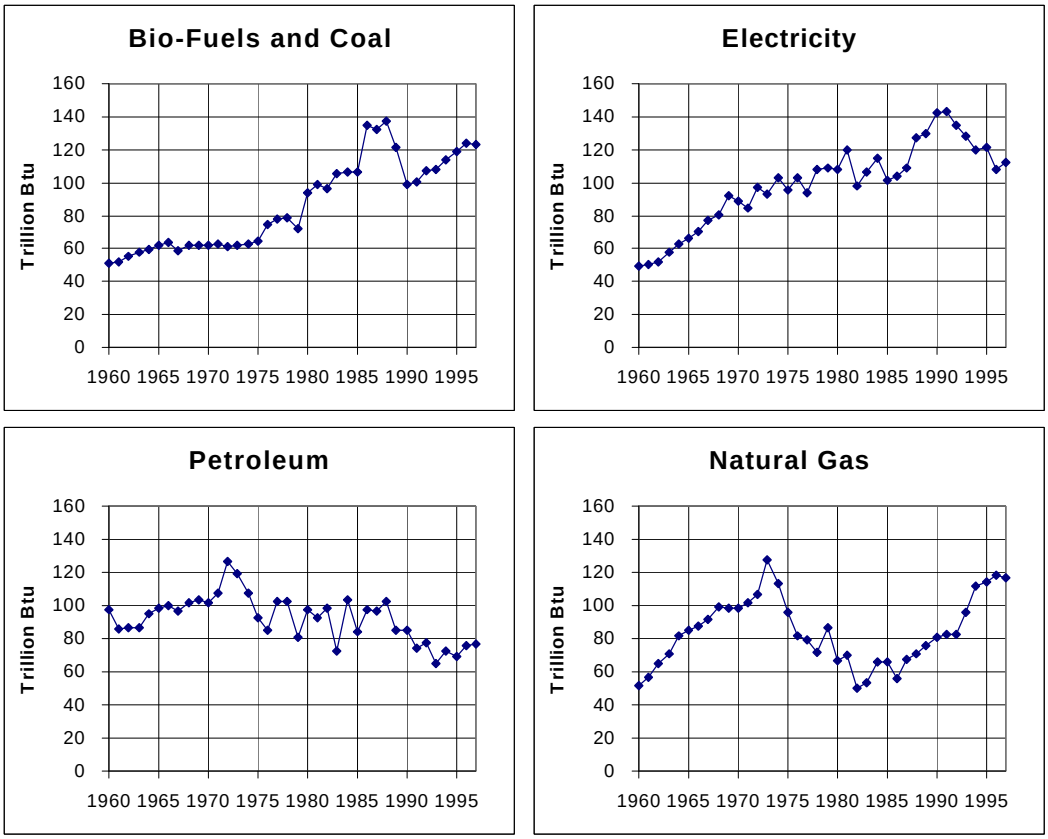
Commercial Sector Energy Consumption per $ of Sector GSP



COMMERCIAL SECTOR ENERGY CONSUMPTION HAS DECLINED RAPIDLY RELATIVE TO ECONOMIC OUTPUT SINCE THE MID-1980S.

Washington's commercial sector has become much less energy intensive over the last 15 years. Commercial sector energy consumption increased more than 50% between 1977 and 1985, but has since grown only slightly. Meanwhile, the value of all goods and services produced by the commercial sector has more than doubled in real terms since 1977 and continues to grow at 4% per year. Increased productivity and improvements in the efficiency of buildings, lighting, and equipment have played major roles in declining commercial sector energy intensity.

14. Industrial Sector Trends — End-Use Energy Consumption by Fuel

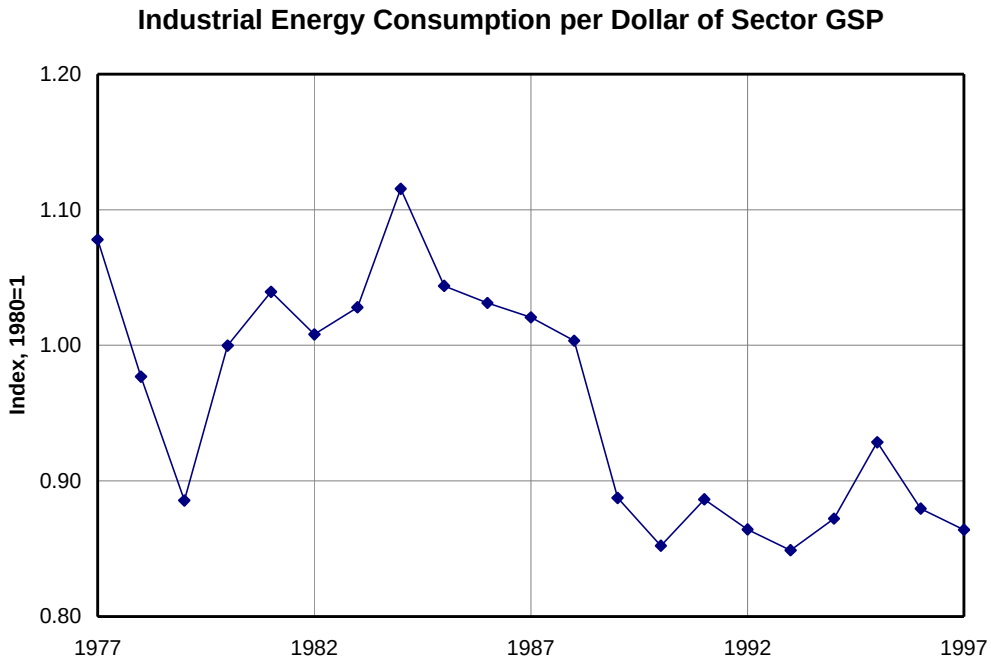


INDUSTRIAL ENERGY CONSUMPTION IN WASHINGTON IS SPLIT MORE EVENLY AMONG BIOFUELS[1], ELECTRICITY, NATURAL GAS, AND PETROLEUM THAN OTHER SECTORS. AS IN OTHER SECTORS, GROWTH IN NATURAL GAS CONSUMPTION HAS ACCELERATED DURING THE 1990S.

Unlike the residential and commercial sectors, which rely primarily on electricity and natural gas, or the transportation sector which consumes almost exclusively petroleum fuels, energy consumption in Washington's industrial sector is quite diversified. Biofuels, electricity, and natural gas each accounted for between 26 and 28% of industrial sector energy consumption during 1997, with petroleum contributing about 18%. With the exception of natural gas, the relative market share of each of the fuels has not changed dramatically since 1970. Natural gas consumption declined precipitously between 1973 and 1983, but growth has accelerated in recent years. Industrial natural gas consumption grew 23% from 1985 to 1990, and 44% from 1990 to 1997.

The industrial sector is the most affected by changes in methodology from the previous edition of Energy Indicators which removed large additional amounts of non-energy petroleum use from our analysis (see Sources and Methodology).

15. Industrial Sector Trends — Industrial Sector Energy Intensity

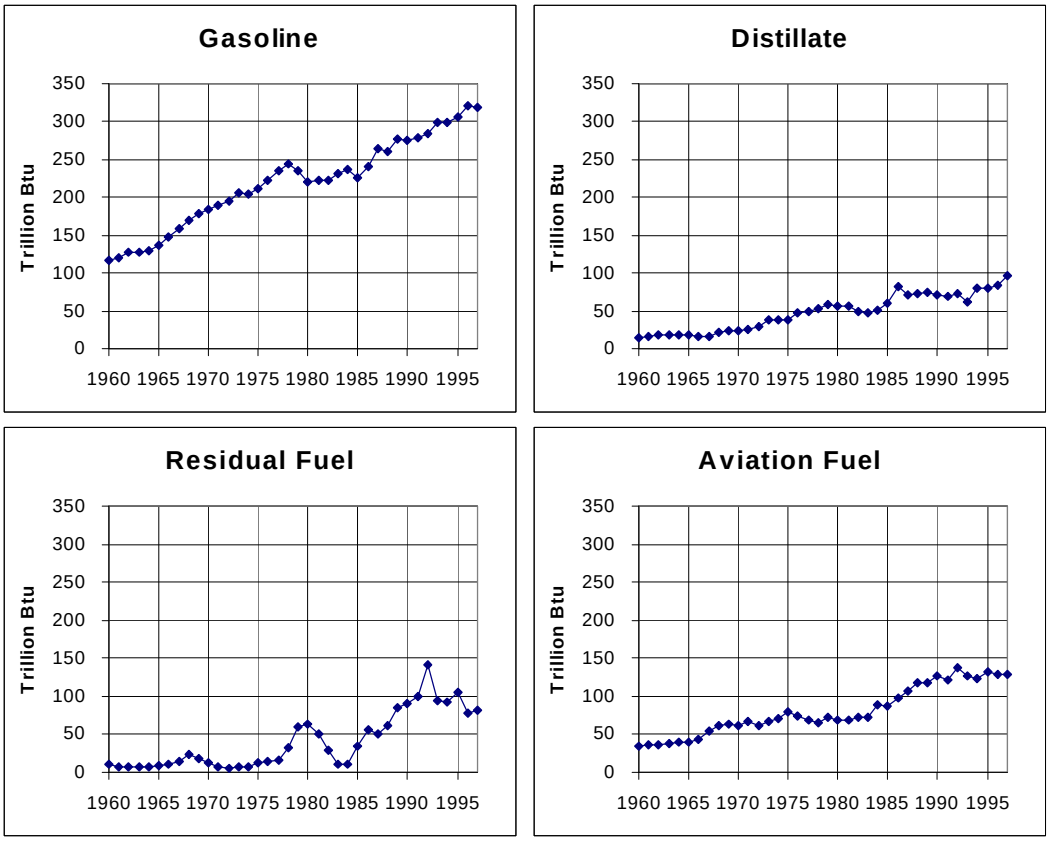


ENERGY INTENSITY IN WASHINGTON'S INDUSTRIAL SECTOR HAS DECLINED OVER THE PAST TEN YEARS, BUT REMAINS MORE VOLATILE THAN OTHER SECTORS.

Washington's industrial sector is less energy-intensive than it was two decades ago, but that is not a consistent trend over that period. Both energy consumption and industrial production are extremely volatile, making it difficult to discern underlying trends. Energy consumption in the industrial sector can vary by as much as 10% from one year to the next. Petroleum energy use in particular commonly lurches up one year and down the next. Industrial production contracted 15% between 1979 and 1985, then grew by 35% between 1985 and 1990, then averaged $31 billion per year in constant, 1996 dollars through 1995 before spiking to above $35 billion dollars in 1997.

It should be noted that we estimate that electricity consumption in the industrial sector is underreported by between 7 and 10% for 1996 and 1997, because the surveys do not report purchases of non-federal power by the direct service industries. With electricity making up slightly more than one fourth of total industrial energy, such a shift would raise the index shown here only slightly, from 0.88 to 0.90 in 1996 and from 0.86 to 0.89 in 1997.

16. Transportation Sector Trends — End-Use Energy Consumption by Fuel

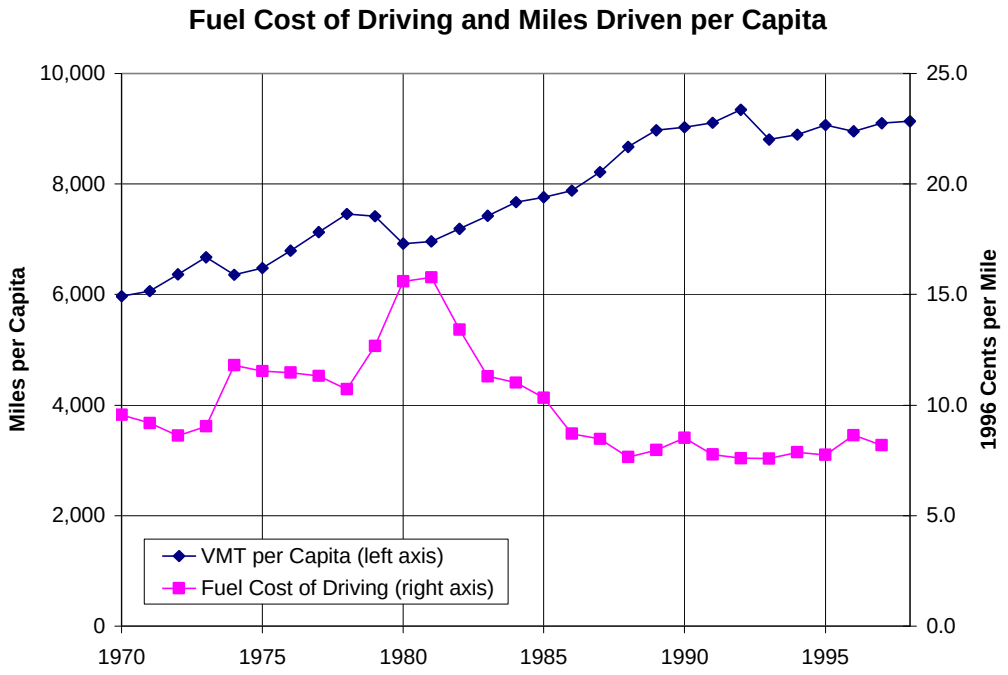


GASOLINE ACCOUNTS FOR HALF OF TRANSPORTATION SECTOR ENERGY USE IN WASHINGTON. WHILE WASHINGTONIANS DRIVE MORE THAN OTHER AMERICANS, WASHINGTON'S STATUS AS A MAJOR SEAPORT AND AVIATION HUB MEANS HIGHER CONSUMPTION OF AVIATION AND MARINE FUELS AS WELL.[1]

Motor gasoline is the dominant transportation fuel, accounting for approximately half of Washington's transportation energy consumption. Except for the period between 1978 and 1986, demand for travel has outstripped gains in vehicle fuel efficiency, leading to steady growth in gasoline consumption. Consumption of distillate fuels in trucks (as diesel fuel), ships, and railroads has also grown. Residual fuel, used for vessel bunkering, is subject to price-induced volatility because it can be stored for long periods of time without degrading.

Jet fuel consumption most closely resembles the overall transportation trends. Declining jet fuel prices have contributed to a significant increase in air travel, overwhelming efficiency improvements in the stock of private, commercial, and military planes. Jet fuel use more than doubled between 1970 and 1997, growing at an average annual rate of 2.9%.

17. Transportation Sector Trends — Fuel Cost of Driving and Miles Driven

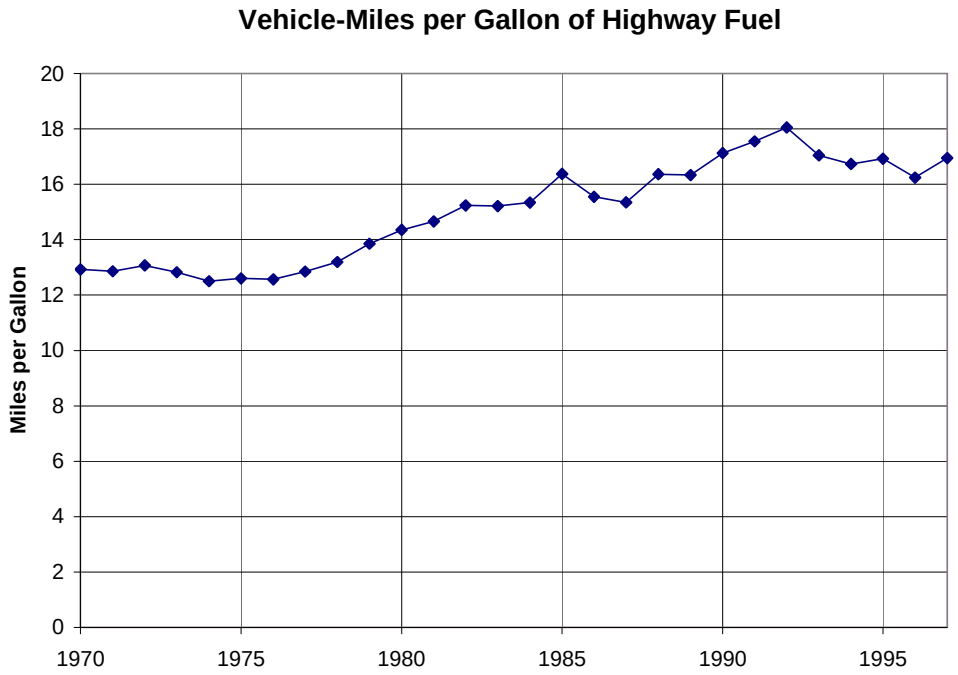


WASHINGTONIANS DROVE 53% MORE MILES PER CAPITA IN 1998 THAN THEY DID IN 1970. A BIG REASON IS THE FUEL COST OF DRIVING, WHICH REMAINED NEAR HISTORIC LOWS.

This indicator juxtaposes the fuel cost of driving with miles per driven per capita in Washington. Not surprisingly, these series exhibit a strong inverse relationship. The fuel cost of driving, calculated as real dollar highway energy expenditures divided by vehicle-miles traveled (VMT), spiked upward in 1974 and 1979-1980 as a result of the oil shocks. VMT per capita dropped slightly in response to higher prices, as unnecessary driving was temporarily curtailed. However, long-term factors such as land-use patterns, commuting habits, and the long lifetimes of vehicles mean that large swings in fuel prices lead to only small changes in miles driven.

Increasing sales of more fuel-efficient vehicles in the early 1980s combined with declines in the price of highway fuels to cause a rapid drop in the fuel cost of driving, from a high of 15.8¢ per mile in 1981 to 8.7¢ in 1986 (in 1996 dollars). Gains in fuel efficiency since the early 1970s made this the lowest value in history. However, real gasoline prices have changed little since 1986, and increases in vehicle fuel efficiency have slowed dramatically as well. Meanwhile, vehicle travel increased steadily before an unexplained drop in 1993.

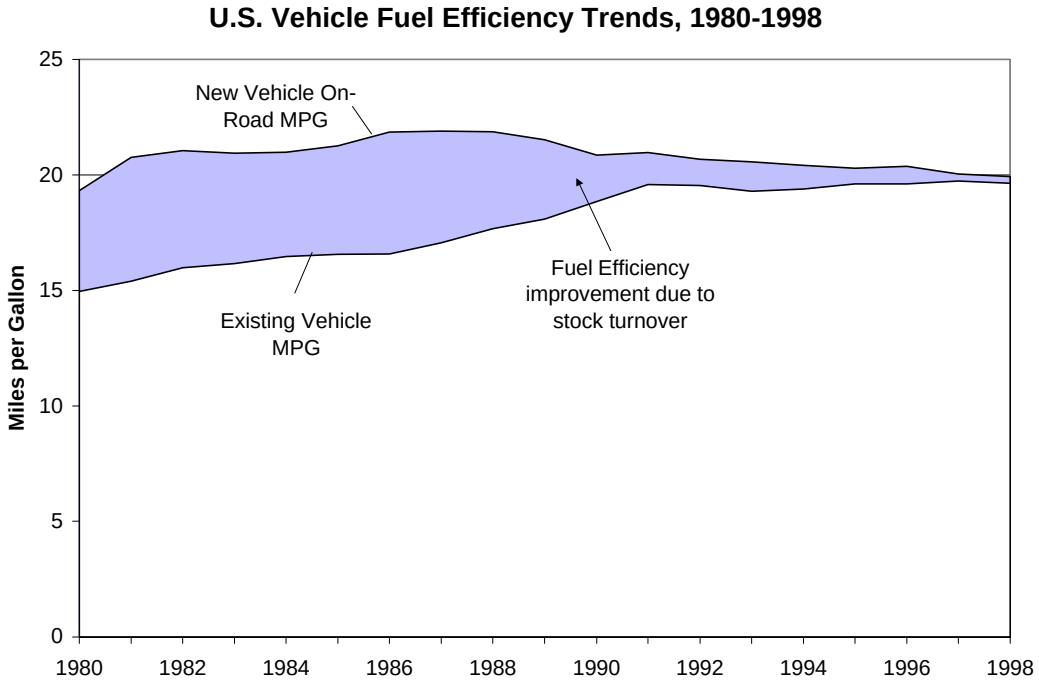
18. Transportation Sector Trends — Transportation Sector Energy Intensity



SPURRED BY HIGH GASOLINE PRICES, VEHICLE FUEL EFFICIENCY INCREASED BY MORE THAN A THIRD BETWEEN 1975 AND 1985[1]. INCREASING POPULARITY OF VANS, TRUCKS, AND SPORT UTILITY VEHICLES IN THE 1990S MAY HAVE PUT AN END TO THAT TREND.

Like other sectors, Washington's transportation sector has become more energy efficient over the years. The average efficiency of Washington's vehicle fleet grew from 12.5 MPG in 1975 to 14.2 MPG in 1980 and 17.0 MPG in 1990. However, fifteen years of improvements in vehicle fuel efficiency appear to have come to an end in the 1990s. In fact, fuel efficiency for new vehicles has declined since the mid-1980s, when federal fuel standards were last tightened. The primary reason is the increasing popularity of minivans, pickups, and sport-utility vehicles.

19. Transportation Sector Trends — U.S. Vehicle Fuel Efficiency

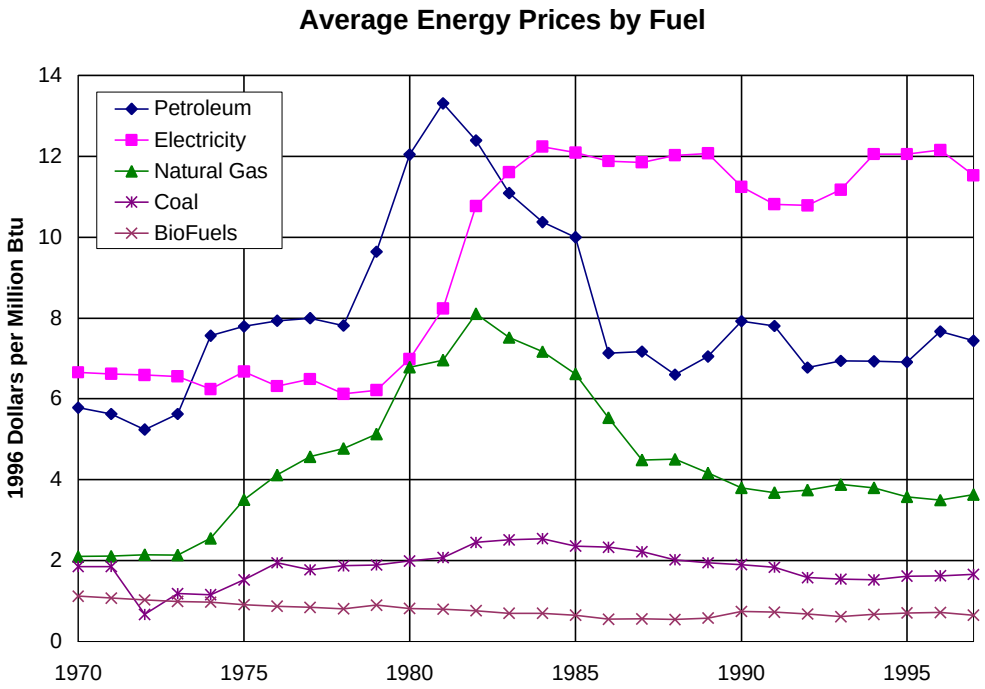


THE FUEL EFFICIENCY ADVANTAGE OF NEW VEHICLES RELATIVE TO THE EXISTING VEHICLE FLEET IS DISAPPEARING. INCREASING POPULARITY OF LARGER VEHICLES, COMBINED WITH THE AGING OF 1980S-ERA SUBCOMPACTS, MAY MEAN AN END TO YEARS OF FUEL EFFICIENCY IMPROVEMENTS.

The difference between the fuel efficiency of new vehicles and that of the nation's existing vehicle fleet continues to shrink and may even have disappeared. New vehicle fuel efficiency has been declining since the mid-1980s, when Congress last increased Corporate Average Fuel Economy (CAFE) standards. CAFE standards require companies to maintain the average fuel efficiency of new vehicles at 27.5 MPG for cars and 20.5 MPG for light trucks (which includes minivans, pickups, and sport-utility vehicles).[1] However, CAFE has no mandates about how many vehicles may be sold in each category, and the increasing popularity of light trucks has caused the fuel efficiency of the average new vehicle to drop by more than two miles per gallon (MPG) since 1988.

Moreover, the vehicles being replaced are no longer 1970s-era gas-guzzlers, but are frequently compact, fuel-efficient, cars of the 1980s. The result is that, unlike in other sectors where newer equipment tends to be more energy efficient, vehicle stock turnover may be leading to a less efficient national fleet. With the average lifetime of light-duty vehicles being more than seven years and little prospect of declining demand for travel, Washington petroleum consumption looks set to increase for some years.

20. Energy Price Trends — Average Energy Prices by Fuel

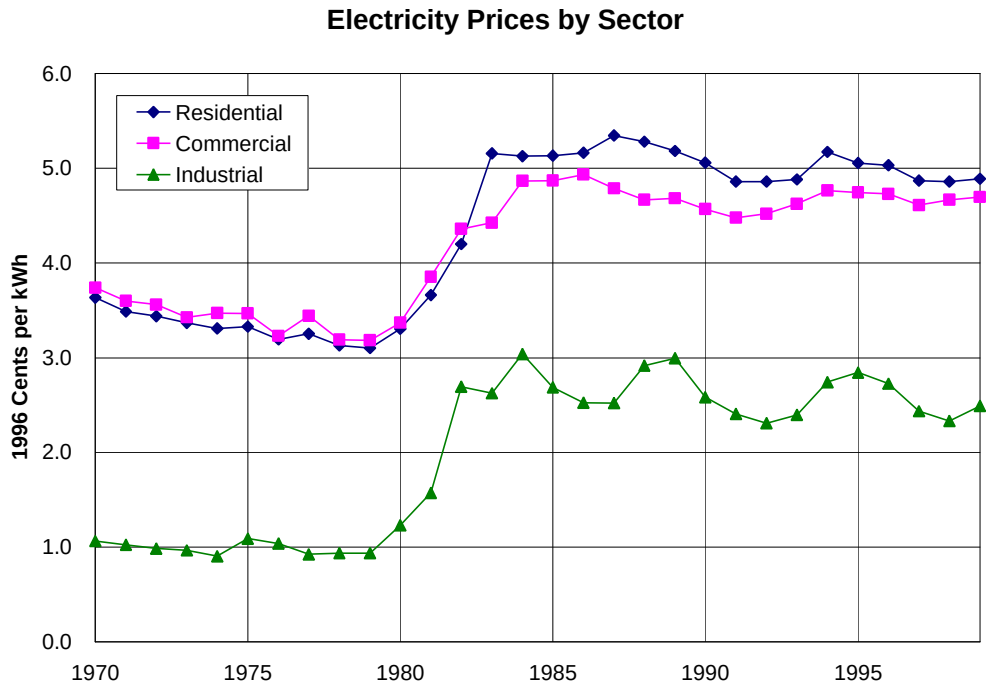


EVEN THOUGH ELECTRICITY PRICES IN WASHINGTON TEND TO BE LOWER THAN IN OTHER PARTS OF THE COUNTRY, ELECTRICITY IS STILL THE MOST EXPENSIVE ENERGY SOURCE. REAL FOSSIL FUEL PRICES HAVE DECLINED SIGNIFICANTLY SINCE THE EARLY 1980'S, BUT AVERAGE ELECTRICITY PRICES HAVE REMAINED CONSTANT.

While the effect of the oil shocks of 1973 and 1978 on Washington energy prices was dramatic, it was relatively short-lived. Petroleum prices increased by 50% in 1974, increased by another 63% between 1978 and 1981, and then quickly settled back to pre-1973 levels. Real natural gas prices have followed a similar trend, rising steeply during the 1970s, falling during the 1980s, and staying relatively stable in the 1990s. The average price of electricity, which had been low and stable for years, increased by 95% between 1979 and 1984 as the costs of new, large power plants, some of which were never completed, were incorporated into electric utility rates. In contrast to oil prices, real electricity prices have not declined from the level they reached during the early 1980s.

The price increases for all fuels caused real Washington energy expenditures to climb by 56% between 1978 and 1982. Expenditures were 25% lower by 1986 as the price of fossil fuels plummeted, but have since climbed back near the levels of the early 1980s, as energy consumption has increased.

21. Energy Price Trends — Average Electricity Prices by Sector

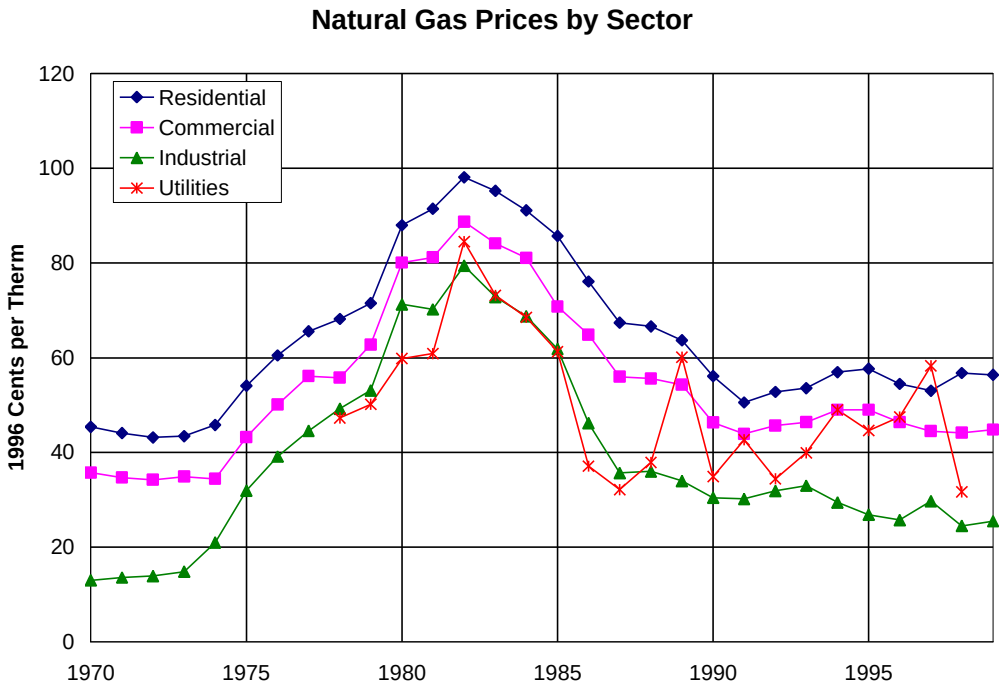


REAL ELECTRICITY PRICES INCREASED DRAMATICALLY BETWEEN 1979 AND 1984 AND STAYED CONSTANT THROUGH 1999. THE MAGNITUDE OF THE INCREASE, PRIMARILY DUE TO NUCLEAR DEBT, WAS SIMILAR FOR ALL SECTORS BUT THE RELATIVE INCREASE WAS MUCH HIGHER FOR THE INDUSTRIAL SECTOR.

The most notable phases in electricity prices are the long, slow decline of prices in the 1970s, the rapid increase between 1979 and 1984, and the period since 1984 when no trend is evident. Price trends for the residential and commercial sectors are nearly identical. Industrial sector prices have been more volatile than residential and commercial prices, increasing over 200% between 1979 and 1984, versus 50-60% for the residential and commercial sectors. On a per unit basis, however, the increases were similar for all sectors: 1.9¢ per kWh for the residential, 1.6¢ per kWh for the commercial, and 2.0¢ per kWh for the industrial sector.

Industrial prices have fluctuated as much as half a cent per kWh from year to year during the 1980s and 1990s. This may have as much to do with world aluminum prices as it does with Northwest electricity prices. Aluminum smelters, which account for nearly half of industrial sector energy consumption in Washington, paid electricity prices contractually linked to aluminum prices for much of the time period depicted.

22. Energy Price Trends — Average Natural Gas Prices by Sector



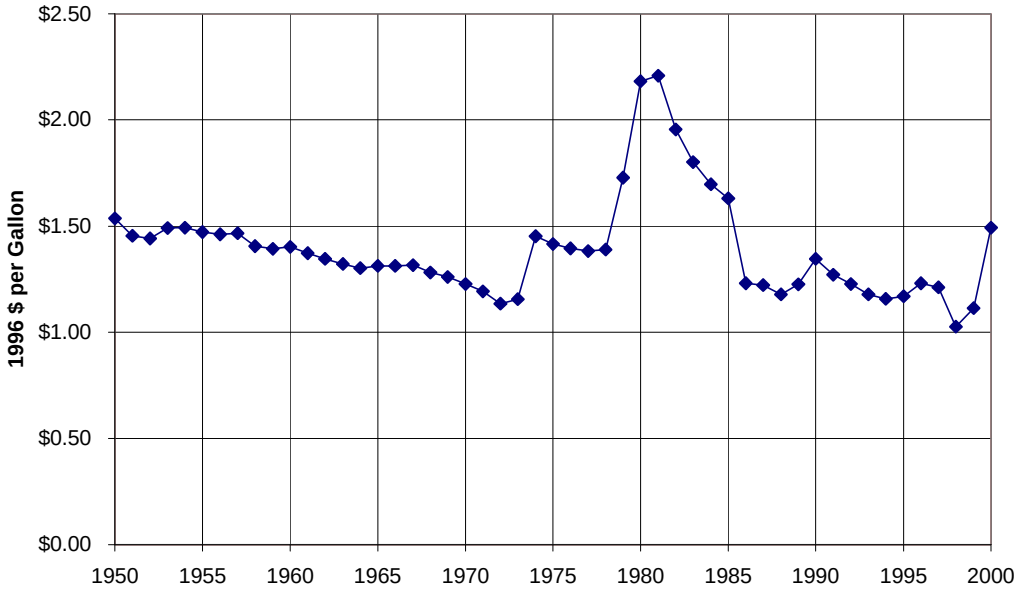
NATURAL GAS PRICES INCREASED RAPIDLY FOR ALL SECTORS BETWEEN 1974 AND 1982 AND DECLINED JUST AS RAPIDLY FROM 1982 TO 1991. INDUSTRIAL SECTOR GAS PRICES HAVE DECLINED SINCE 1993, WHILE RESIDENTIAL AND COMMERCIAL RATES HAVE SEEN MODEST INCREASES.

Price trends for natural gas have been much more uniform across sectors than for electricity. For all sectors, real prices were stable in the early 1970s, increased rapidly between 1974 and 1982, and declined just as rapidly between 1982 and 1991. As with electricity, the price increases during the 1970s were of similar magnitude in all sectors on a per unit basis, but were much larger in percentage terms for the industrial sector. Real natural gas prices increased by approximately 50¢ per therm for all sectors between 1973 and 1982.

Price trends have diverged in the 1990s. Residential and commercial customers experienced price increases of 11.5% and 2%, respectively, between 1991 and 1999. Average industrial sector natural gas prices declined by 15.5% over the same period. Many large industrial customers have begun to make bulk purchases of commodity gas from suppliers other than their local utilities. Natural gas in the utility sector has historically been used to fire relatively small power plants used for “peaking“, which at least partially explains the volatility experienced in that sector. With a number of gas-fired plants in the planning stages, utility sector consumption of natural gas will soon become much more significant.

23. Energy Price Trends — U.S. Gasoline Prices since 1950

Real U.S. Gasoline Prices, 1950-2000

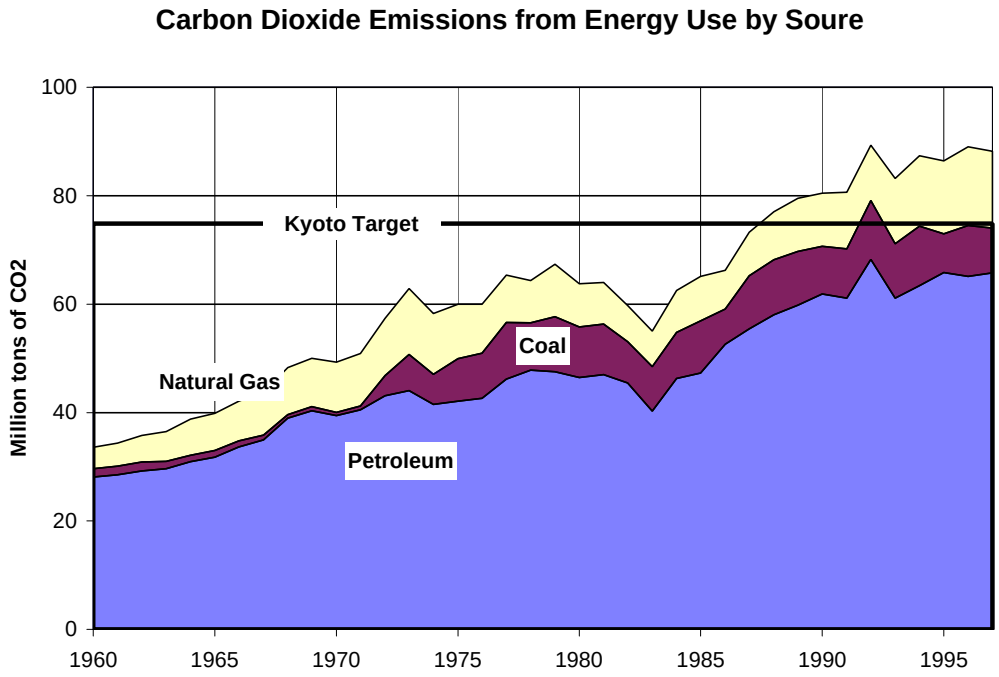


ADJUSTED FOR INFLATION, GASOLINE COST LESS IN 1998 AND 1999 THAN AT ANY TIME IN HISTORY. PRICES ROSE SUBSTANTIALLY IN 2000[1], TO LEVELS NOT SEEN SINCE THE HEYDAY OF OPEC IN THE MID-1980S.

After falling to their lowest levels in history in February, 1999, U.S. gasoline prices rose 50¢ per gallon over the next 12 months. The increase was kicked off by a two million barrel per day cut by the Organization of Petroleum Exporting Countries (OPEC) in March 1999, but years of declining fuel efficiencies and increasing consumption left the country more vulnerable than it had been to supply shocks.

Before 1999, the dominant trend in gasoline prices was slow and steady decline, with the exception of the 1973-1985 period of OPEC unity. The discovery of new fields, better technology, and improved infrastructure have reduced the cost of extracting, transporting, and refining crude oil. Prices plunged when the OPEC agreements fell apart in 1985, and stayed relatively low until the events of 1999. Adjusted for inflation to 1996 dollars, a gallon of gasoline cost $2.18 in 1980, $1.23 in 1970, and $1.54 in 1950, as compared to $1.49 through the first nine months of 2000.

24. Environmental Trends — Energy-Related Greenhouse Gas Emissions



WASHINGTON'S INCREASING RELIANCE ON FOSSIL FUELS HAS LED TO STEADY GROWTH IN EMISSIONS OF CARBON DIOXIDE, THE PRINCIPAL GREENHOUSE GAS. PETROLEUM USE, PRIMARILY FOR TRANSPORTATION, ACCOUNTS FOR 75% OF CO_2 EMISSIONS IN WASHINGTON.

Washington's continued dependence on fossil fuels for energy, particularly petroleum, has led to rapid growth in emissions of carbon dioxide (CO_2), the principal "greenhouse gas" contributing to global climate change.[1] After dipping in the early 1980s, growth in carbon dioxide emissions accelerated after 1983 as the economy recovered from recession and oil prices plummeted. Washington's CO_2 emissions from energy use grew by 2.6% per year between 1985 and 1997.

Consumption of petroleum products, the vast majority for transportation, accounts for three-quarters of Washington's CO_2 emissions. Emissions from coal are almost entirely from one source, the Centralia Steam Plant which burns coal to produce electricity. Natural gas contains less carbon per unit of energy than other fossil fuels, but still accounts for a larger share of Washington's CO_2 emissions than coal.

Also depicted is the emission target agreed to during the Kyoto negotiations in 1997, which is 7% below 1990 levels. Meeting this target would require a 15% reduction from Washington's 1997 emissions level.

Sources and Data Notes

1 Washington's Energy Use — End-Use Energy Consumption By Sector

Source: Energy Information Administration's State Energy Data System

2 Washington's Energy Use — Primary Energy Consumption by Source

Source: Energy Information Administration's State Energy Data System

Note 1: EIA uses each state's mix of electric generation to map electricity consumption to production by primary fuels. This overstates the contribution of hydroelectricity, as Washington is part of an interconnected regional electric grid and relies on generation sources in other states that are less hydroelectric-intensive. (See Indicator #3).

Note 2: The difference between primary and end-use energy consumption is the treatment of electricity. Electricity must be generated using energy sources such as coal, natural gas, or falling water. These inputs to the power plant are counted as primary energy; the output of the power plant that is sold to homes and businesses is end-use electricity. Since two-thirds of the energy inputs to thermal power plants are typically lost as waste heat, primary energy is larger than end-use.

3 Washington's Energy Use — Electricity Generation

Source: Energy Information Administration, Electric Generator Database

Note 1: The U.S. portion of the Northwest Power Pool includes Washington, Oregon, Idaho, Montana, and parts of Wyoming and Nevada.

Note 2: The Western Interconnection refers to the geographical area encompassed by the interconnected western transmission grid. It includes all or most of Washington, Oregon, Idaho, Montana, Wyoming, Utah, Nevada, Colorado, New Mexico, Arizona, California, the Canadian provinces of British Columbia and Alberta, and the Mexican state of Baja California Norté. It also includes small portions of Texas, Nebraska, and South Dakota.

4 Washington's Energy Bill — End Use Energy Expenditures

Sources: Energy Information Administration's State Energy Data System; Council of Economic Advisors, The 2000 Annual Economic Report of the President

5 Washington's Energy Intensity — Energy Consumption per Dollar of Gross State Product

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis

6 Washington's Energy Intensity — Energy Consumption per Capita

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of the Census

7 Washington's Energy Intensity — Energy Expenditures per Dollar of Washington GSP

Sources: Energy Information Administration's State Energy Data System; Bureau of Economic Analysis

Note 1: Energy expenditures include expenditures by households as well for personal transportation.

8 Residential Sector Trends — End-Use Energy Consumption by Fuel

Source: Energy Information Administration's State Energy Data System

Note 1: The primary petroleum products consumed in households are heating oil (No. 2 distillate oil) and propane. Both are consumed mainly for space heating, though propane can also be used for cooking and water heating.

9 Residential Sector Trends — Household Energy Intensity

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of the Census

10 Residential Sector Trends — Household Energy Bill

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of the Census

11 Residential Sector Trends — Household Energy Bill with Transportation

Source: Energy Information Administration, Residential Energy Consumption Survey

Note 1: These detailed figures about household energy expenditures were obtained from a different source than data used elsewhere in this report. As a result, this estimate of the average household energy bill differs slightly from that in the previous indicator.

12 Commercial Sector Trends — End-Use Energy Consumption by Fuel

Source: Energy Information Administration's State Energy Data System

13 Commercial Sector Trends — Sector Energy Intensity

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis

14 Industrial Sector Trends — Energy Consumption by Fuel

Source: Energy Information Administration's State Energy Data System

Note 1: Bio-fuels consumed in the industrial sector comprise mainly wood and wood waste products such as black liquor or hog fuel. These fuels are primarily burned in industrial boilers to make steam, which can be used to fire industrial processes or to generate electricity for on-site use. Industrial coal consumption has declined from a high of 14 trillion Btus in 1976 to 3 trillion Btus in 1997.

15 Industrial Sector Trends — Industrial Sector Energy Intensity

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis

16 Transportation Sector Trends — End-Use Energy Consumption by Fuel

Source: Energy Information Administration's State Energy Data System

Note 1: Motor gasoline figures include some consumption for off-road uses such as recreational vehicles and agricultural uses. No. 2 distillate, also known as diesel fuel, is used by large trucks, ships, and railroads. The only transportation use for residual fuel is by very large ships. Aviation fuel includes kerosene-based jet fuel used by major airlines, aviation gasoline consumed by smaller airplanes, and military jet fuel.

17 Transportation Sector Trends — Fuel Cost of Driving and Miles Driven per Capita

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of the Census; U.S. Department of Transportation, Federal Highway Administration

18 Transportation Sector Trends — Transportation Sector Energy Intensity

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Transportation, Federal Highway Administration

Note 1: Data includes fuel consumption by heavy-duty trucks in addition to personal vehicles.

19 Transportation Sector Trends — US Vehicle Fuel Efficiency Trends

Sources: Energy Information Administration's State Energy Data System; Oak Ridge National Laboratories

Note 1: Official, EPA-rated fuel efficiency. The Energy Information Administration estimates actual, on-road performance to be 13.9% worse than the EPA rating for cars and 18.6% worse for light trucks (EIA, *National Energy Modeling System*, Fuel Economy Degradation Factor). This means that the average fuel economy of vehicles sold in 1998 is 19.9 MPG, as opposed to 23.9 estimated by EPA. This is very close to the average, on-road fuel efficiency of the nation's existing stock of light-duty vehicles, which is estimated to be 19.6 MPG (Oak Ridge National Laboratory, *Transportation Energy Data Book*).

20 Energy Price Trends - Average Energy Prices by Fuel

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis

21 Energy Price Trends - Average Electricity Prices by Sector

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis

22 Energy Price Trends - Average Natural Gas Prices by Sector

Sources: Energy Information Administration's State Energy Data System; U.S. Department of Commerce, Bureau of Economic Analysis

23 Energy Price Trends - US Gasoline Prices since 1950

Source: Energy Information Administration's Annual Energy Review;

Note 1: 2000 value is an estimate based on data for January-September.

24 Environmental Trends - Energy-Related Greenhouse Gas Emissions

Sources: Energy Information Administration's State Energy Data System, Kyoto Protocol

Note 1: These estimates include emissions of greenhouse gases due to the use of petroleum coke as a reactant in industry, which is arguably not “energy-related”. However, there are some additional energy-related emissions of greenhouse gases not due to the combustion of fuels that are not included in this indicator. These include releases of methane (CH_4) from coal mining and natural gas pipeline leakage and nitrous oxide (N_2O) released from catalytic converters used on light duty automobiles. These emissions accounted for about 6% of Washington’s total, energy-related greenhouse gas emissions in 1995.

Methodology

Introduction

Most publicly available comprehensive energy data at the state level originate with surveys and estimates developed by the Energy Information Administration (EIA), an independent branch of the federal Department of Energy. We rely heavily on the EIA's State Energy Data System (SEDS) to produce Energy Indicators and other products. However we modify data from the EIA, based on years of experience with their components and their fit with the needs of the Energy Indicators.

Modifications to Source Data

Readers of the previous edition may notice a significant difference in several indicators. Most of the change is due to a revision in our methodology involving the treatment of petroleum products used in industrial processes, but not as fuels. This resulted in significant changes in the industrial sector, especially in the most recent 15 years. We also differ with EIA's approach to calculating the energy value for hydroelectricity in primary views. Additionally, since the publication of the previous Indicators, the EIA has provided a complete series on biofuels for all sectors. Originally, these data were provided only when used as inputs to generate electricity. A partial record was later established, with the series beginning in 1990, requiring us to generate estimates for missing years. Now a complete series is available from EIA, and it differs significantly from our earlier estimates.

Excluded Petroleum Products

In the previous edition, we excluded asphalt, road oil, and lubricants from the transportation and industrial sectors. These are easily removed series that are clearly not used as energy sources. In this edition we have removed additional non-energy petroleum products.

Among the products excluded from our energy analysis is industrial petroleum coke, used in various forms as a source of pure carbon. We have also excluded other uses such as petroleum used as feedstock for paints and solvents, or to make waxes to coat packaging. The focus of this analysis is energy consumption in Washington, rather than the supply of and demand for petroleum products or other fossil fuels. Excluding these non-energy uses provides the most accurate picture of the consumption of energy in the state.

The EIA series for industrial coke comprises coke used in oil refining and primary aluminum smelting. Neither of these processes uses coke for its energy content, but rather for its catalytic and conductive properties. These two types of coke are allocated to states, not according to measured use at the state level, but instead based on their share of the United States' annual capacity in the respective industries multiplied against US industrial coke use. The capacity of both these industries has grown considerably in Washington, and their share of the US total has also grown.

Indexed against 1970, the first year in which data pairs showing consumption and expenditure are available in SEDS, the Washington aluminum industry expanded by almost a third by 1997, and represented the largest primary smelting share of any state, at 29% of the nation's total.

While representing a much smaller share of the nation's petroleum refining industry, Washington's oil refineries have seen continued growth throughout the span of the data in these Indicators, while US capacity has changed little since the mid-80s.

The effect of these growing industries combined with the EIA inclusion of the (non-energy) petroleum coke they use as industrial energy consumption has resulted in distortion of the true patterns of industrial energy consumption, and thus an inflated view of energy use overall in Washington. That effect is magnified in the past two decades, when at

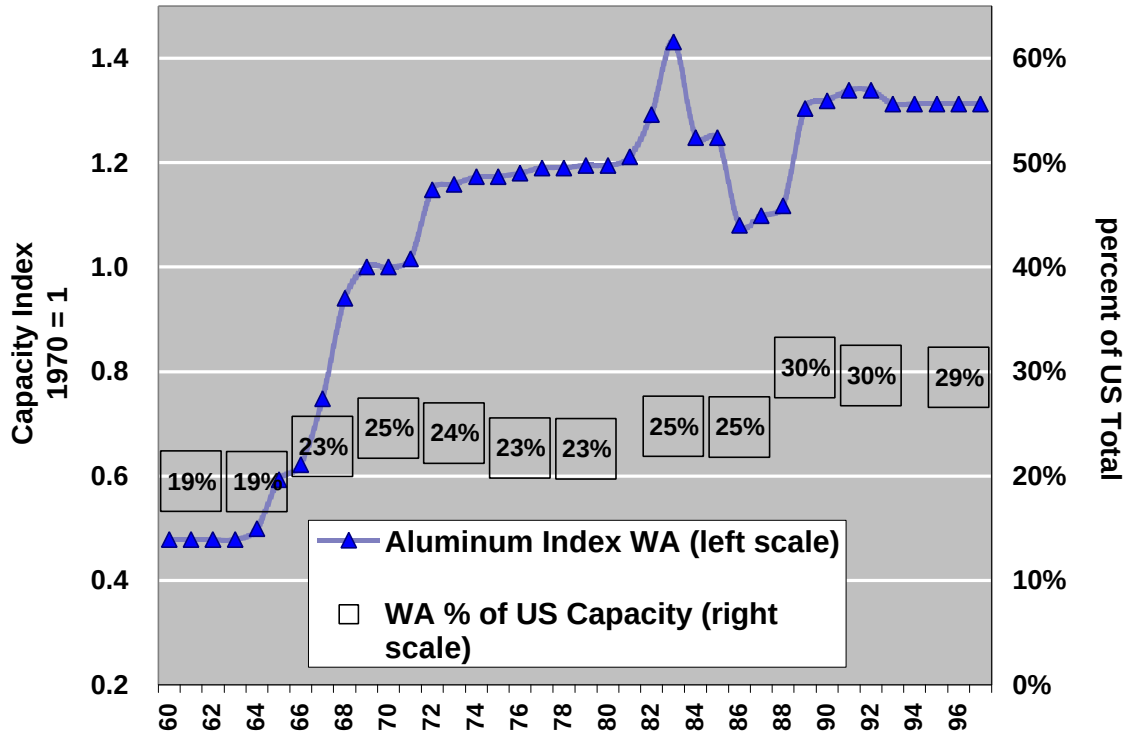


Figure 20 Washington Aluminum Ingot Capacity

Source: EIA SEDS

their peak, these non-fuel petroleum products accounted for more than 1/4th of the total Washington industrial energy use claimed by the EIA.

Non-utility Electricity Sales

An issue which does not represent a shift in methodology but which also hampers attempts to depict comprehensive energy use trends accurately is the changing nature of the electricity industry. Electricity is increasingly supplied to end-users by non-utility providers, out-of-state utility power marketers, or is generated on-site in many industrial facilities. Beginning in 1996, aluminum producers in Washington began to purchase power from such providers. These purchases escaped the utility focus of the EIA's collection efforts for the SEDS. Only for recent years not included in these Indicators are detailed totals of those sales becoming clearer. We anticipate a more accurate historical record of industrial electricity consumption to emerge in the next eighteen months. For this version of the Indicators, we estimate that electricity consumption in the industrial sector is underreported by between seven and 10% for 1996 and 1997.

However, it should be noted that the fuels used to power on-site industrial electric generation are reflected in that sector's totals, not as kilowatt-hours consumed but as fuel burned. So a small amount of the biomass, natural gas, and other fuels shown there can be assumed to be used to power on-site generation.

Hydroelectric Conversion

One last methodological note must be made to explain the differences one may notice here compared to other tallies of state energy use. In a steam powered generator, as much as two-thirds of the heat in the fuel burned to produce electricity is lost. Hydroelectric power generation does not experience thermal losses, but the EIA assigns losses to it equivalent to an average

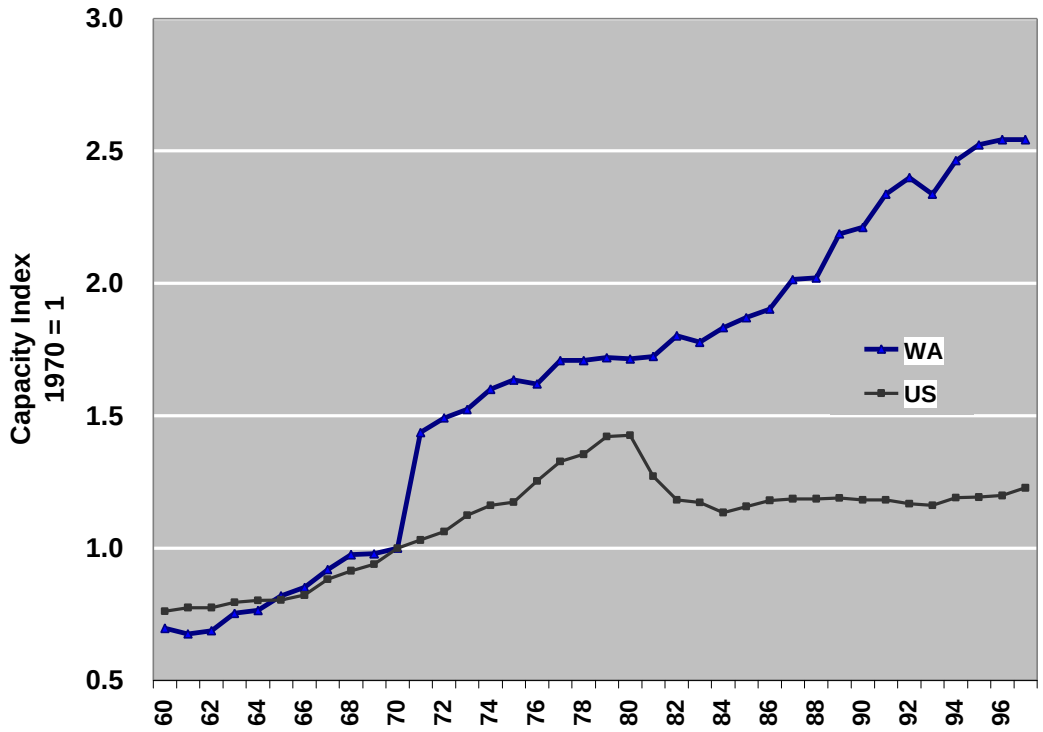


Figure 21 Washington's Operating Oil Refining Capacity

Source: EIA SEDS

loss rate for fossil fuel powered generation, in an effort to enable comparison of primary energy consumption between individual states. We remove those imputed losses from our primary totals. This difference does not affect depictions of sector end-use consumption of energy, as these do not show primary consumption.

Methodology Summary

In summary, large amounts of non-energy petroleum products used in aluminum smelting and oil refining, significant purchases of electricity in recent years other than from in-state utilities, and the large role hydroelectricity plays in the state's energy supply require modifications to standard views of energy consumption to portray accurately the trends depicted in these Indicators.